RP 03755

Grain Quality and Biochemistry
Progress Report-3/86

Chickpea and Pigeonpea

REPORT OF WORK

January - December 1985

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
Patancheru, Andhra Pradesh 502 324, India

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Foreword

This report has been prepared to share the information with scientists who have an interest in grain quality and biochemistry aspects of chickpea and pigeonpea improvement.

THIS IS NOT AN OFFICIAL PUBLICATION OF ICRISAT AND SHOULD NOT BE CITED.

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C H I C K P E A

C-125(85)IC : Grain quality improvement in chickpea

Research activities carried out on chickpea during this year are summarised broadly under the following three categories :

1) Cooking quality and consumer acceptance

2) Protein content and amino acid composition

3) Biological evaluation of protein quality

1. Cooking quality and consumer acceptance:

This area of research continues to receive our greater attention. One of the objectives of the project on quality improvement in chickpea places considerable emphasis on the identification of major food forms of chickpea consumption in the world in general and tropical and subtropical regions in particular where chickpea is consumed to a certain extent as a dietary component. To identify the major food preparations of chickpea a questionnaire was developed and addressed to chickpea scientists through the International Chickpea Newsletter and the responses are awaited. The questionnaire addressed to chickpea scientists through International Chickpea Newsletter is appended (Appendix 1).

Earlier to this, a questionnaire on utilization of chickpea was sent to 74 scientists in 40 countries. Responses were received from 23 scientists from 19 countries. In India, our village level survey has indicated that dhal and food items prepared from chickpea flour (besan) are the major form of chickpea consumption. In other countries, it appears that chickpea is consumed as a whole-seed in the form of vegetable (fried curry/plain boiled and fried), canned and roasted products. This underlines the need for studying the cooking quality of whole-seed as well. Chickpea soup is also a common preparation in some countries. A few food recipes of chickpea have also been noted.

Cooking quality of some elite lines of chickpea was studied. Cooking time and protein content of dhal and 100 grain weight of ICCC 36, ICCC 37, ICCC 42, and Annigeri grown during 1984/85 season are given in Table 1. This table also shows the results of these characteristics of ICCC 36, ICCC 37, and Annigeri grown during 1982/83 season. A considerable variation in these characteristics was noticed when the results of these two seasons were compared. During 1984/85 season, ICCC 42 required the longest cooking time followed by Annigeri, ICCC 36, and ICCC 37. While ICCC 42 was not evaluated in 1982/83 season, other genotypes did not show large differences with respect to these characteristics during this season (Table 1).

2. Protein content and amino acid composition :

We continue to monitor the protein quality of breeding material and germplasm accessions and for this purpose 428 whole seed samples supplied by the breeders and 1246 whole-seed samples received from the Genetic Resources Unit were analyzed. The protein content of breeding lines ranged between 14.3 and 24.7% and for germplasm accessions it was between 9.5 and 20.0%. In consultation with breeders, we observed that about 25% of the breeding lines showed lower protein content than Annigeri (18.3%), used as a check, and these lines may be discarded upon confirmation during next year. The protein values for the breeding lines analyzed during 1985 have been reported (Appendix 2).

To study the effect of date of planting on protein content, a preliminary experiment was conducted. Each of four cultivars, Annigeri, K-850, ICCV-2, and ICCV-4 was planted on 23 October, 7 November, 22 November, and 7 December, 1984 in pots filled with field black soil in three replications. The average protein content of these cultivars was highest in case of late-November planting followed by early-December, early-

November and late-October plantings (Table 2). Even though it was a preliminary trial, results indicated a considerable influence of planting time on protein content in chickpea. Additional studies in this direction will be very useful.

In order to study the variation in protein content of chickpea grown in different fields, four genotypes (ICCC 36, ICCC 37, ICCC 42, and Annigeri) were grown by the breeding program in three different fields at ICRISAT Center. The results of protein analysis of dhal and whole-seed samples of these genotypes are summarised in Table 3. Protein content of these genotypes when grown in different fields ranged between 14.9 and 19.7 for whole-seed samples and between 17.5 and 22.5% for dhal samples. Larger variation in protein content was observed in case of Annigeri as compared to other genotypes. Protein content of Annigeri was lowest in BP2 field and highest in BUS 8 field. Although the results show the effect of field conditions on protein content, it is difficult to point out the specific reason for this variation.

Protein quality is assessed by comparing its amino acid composition with standard reference protein, the most limiting amino acid determining the nutritive value. Like other food legumes, sulphur containing amino acids, methionine and cystine are the primary limiting amino acids in chickpea. Amino acid composition of advanced lines (ICCC 36, ICCC 37, and ICCC 42) developed at ICRISAT was studied in comparison with check sample G 130 (Table 4). Sulphur containing amino acids (methionine + cystine) of ICCC 36, ICCC 37 and ICCC 42 were slightly lower than cv G 130 (Table 4). These lines also showed lower protein values. However, the lysine content of these lines was slightly higher than G 130. Threonine has been reported to be deficient in some cultivars of chickpea. These results show that the threonine content of the lines developed by ICRISAT is noticeably higher than G 130.

3. Biological evaluation of protein quality :

Biological evaluation of protein is important because chemical analysis does not always reveal how much of a protein is biologically available. The protein advisory group of the FAO in 1973 recommended the use of rat as the experimental animal for bioassay procedures, particularly for protein quality improvement work in plant breeding programs. These assay methods fall into two categories : 1) growth methods, protein efficiency ratio (PER), net protein retention (NPR), and relative protein value (RPV) and 2) nitrogen balance methods true digestibility (TD), net protein utilization (NPU) and biological value (BV).

Using 5 Wistar strain male rats per diet, nitrogen balance studies were carried out on some lines of chickpea and biological value, true digestibility and net protein utilization along with values for 100-grain weight, seed coat percent and phenolic compounds are presented in Table 5. These lines were studied because of their reported susceptibility/resistance to pod borer attack. True digestibility of protein of these lines ranged between 85.2 and 90.2% whereas for Annigeri it was 88.8%. These values show that digestibility of chickpea is quite satisfactory in comparison with other food legumes. No clear cut differences between these lines and Annigeri were observed with respect to biological value, true digestibility and net protein utilization. Also, noticeable differences were not observed when low pod borer and high pod borer lines were compared. Generally, phenolic compounds are known to interfere with protein digestibility. But the present results did not support this convention as no relationships seem to exist between protein digestibility and total phenolic contents of chickpea seed coat.

Future Plan :

In future, it is planned to study the cooking quality of more advanced breeding lines. Also the cooking quality and consumer acceptance of desi and kabuli cultivars would be studied in detail.

Pakoda and bread making quality of desi and kabuli cultivars will be examined. Also, the puffing quality of a limited number of cultivars of desi and kabuli types will be studied with the help of local traders. Physicochemical properties of starches of desi and kabuli cultivars will be studied in relation to the food products as mentioned above.

Qualitative and quantitative losses as a result of dehulling of pulses in India have been reported. The influence of dehulling on nutrient losses in chickpea will be studied using Tangential Abrasive Dehulling Device (TADD).

Protein content of breeding lines will be monitored and lines showing protein content below the control may be discarded upon confirmation. Efforts are being made to study the effect of environments including field conditions, moisture stress, fertilizer and inoculation on protein content in chickpea in collaboration with breeding and agronomy subprograms. Amino acid composition of more genotypes and advance breeding lines should be determined and efforts in this direction will continue. Also, these lines will be biologically evaluated by conducting rat feeding trials.

Effect of storage on nutritional quality including cooking quality has often been emphasized. We plan to initiate an experiment on long term storage and study its effect on nutritional quality of chickpea when stored at different temperatures.

Table 1 : Grain weight, protein content, and cooking time of ICCC 36, ICCC 37, ICCC 42, and Annigeri.

Cultivar	100-grain wt (g)		Dhal protein[c] %		Dhal cooking time[d] (min)	
	a	b	a	b	a	b
ICCC 36	14.8	13.4	26.6	24.6	30	31
ICCC 37	17.0	14.5	26.6	19.2	31	28
ICCC 42	-	24.5	-	24.3	-	40
Annigeri*	16.2	22.3	23.6	21.3	29	32
Mean	16.0	18.7	25.6	22.4	30	32.8
SE	± 1.11	± 5.55	± 1.73	± 2.53	± 1.0	± 5.12

[a] 1982/83; [b] 1984/85; grown at ICRISAT Center,

[c] average of two determinations; [d] average of three determinations.

* During 1982/83, grown at Derol, Gujarat, India.

Table 2 : Effect of date of planting on protein content in chickpea[a].

Cultivar	Planting time (1984)			
	23 October	7 November	22 November	7 December
	Protein (%)			
Annigeri	17.8	18.7	21.3	22.1
K-850	22.3	25.0	26.1	23.9
ICCV-2	21.8	22.9	25.1	23.3
ICCV-4	17.9	20.0	23.8	23.3
Mean	20.0	21.7	24.1	23.2
SE	± 2.43	± 2.84	± 2.08	± 0.75

[a]Pot experiment conducted at ICRISAT Center.

Table 3 : Protein content of chickpea genotypes grown in different fields at ICRISAT Center in 1984/85 season.

Genotype	Whole-seed protein (%)[a]			Dhal protein (%)[a]		
	BP 2	BM 8	BUS 8	BP 2	BM 8	BUS 8
ICCC 36	17.5	19.7	18.7	20.2	22.5	22.2
ICCC 37	17.0	17.0	17.5	20.0	19.2	20.4
ICCC 42	16.7	16.6	15.7	18.8	19.9	18.4
Annigeri	14.9	16.8	18.8	17.5	19.3	21.4
Mean	16.5	17.5	17.7	19.1	20.2	20.6
SE	± 1.13	± 1.46	± 1.44	± 1.25	± 1.55	± 1.64

[a] Mean of ten determinations.

Table 4 : Amino acid (g/100g protein) composition of defatted dhal sample of four genotypes grown at ICRISAT Center in 1984/85 season

Amino acid	G-130[a]	ICCC 36	ICCC 37	ICCC 4[illegible]
Aspartic acid	10.40	10.28	10.64	10.23
Threonine	3.03	3.92	3.68	3.79
Serine	4.40	5.10	5.07	5.07
Glutamic acid	15.74	18.04	18.33	18.62
Proline	3.78	4.48	4.48	4.56
Glycine	3.72	3.96	3.61	3.81
Alanine	3.72	4.22	4.11	4.16
Histidine	2.77	2.83	2.75	2.76
Lysine	6.43	6.77	6.72	6.64
Arginine	9.38	8.02	7.79	8.19
Cystine	1.12	1.19	1.26	1.27
Valine	4.23	4.72	4.69	4.62
Methionine	1.79	1.34	1.34	1.30
Isoleucine	4.02	5.30	5.47	5.30
Leucine	7.02	7.80	7.43	7.59
Tyrosine	2.89	3.36	3.32	3.35
Phenylalanine	5.21	5.59	5.62	5.91
Total	89.68	97.80	96.87	97.86
Protein (%)	25.15	24.60	19.22	24.30

[a]Used as a laboratory check.

Table 5 : Biological evaluation of some lines of chickpea grown at ICRISAT Center in 1984/85 season

Genotype	100-grain wt (g)	Seed coat (%)	Phenolics (%)	BV	TD	NPU
				......	%	......
ICC 506[a]	15.7	19.5	0.74	68.4	86.2	59.0
IC-738-8-1-1P[a]	13.2	18.1	0.57	73.2	87.5	64.1
IC-7341-8-1-1P[a]	14.8	14.8	0.62	69.1	85.2	58.9
IC-7320-11-1-1H[a]	11.8	19.2	0.65	70.0	88.8	62.1
ICC-3137[b]	29.6	13.1	0.27	69.8	90.2	63.0
Annigeri	20.3	14.3	0.54	68.8	88.8	61.0
Mean	17.6	16.5	0.57	69.9	87.8	61.3
SE	± 6.61	± 2.76	± 0.160	± 1.73	± 1.85	± 2.12

[a] Low borer line, [b] High borer line. BV = biological value,

TD = true digestibility, NPU = net protein utilization.

APPENDIX - I

UTILIZATION OF CHICKPEAS - A QUESTIONNAIRE
(Please use additional sheet if necessary)

1. Chickpeas are utilized in the preparation of the following commonly used food items (give local names):

A	B	C
____________________	____________________	____________________
____________________	____________________	____________________

2. Indicate the preferred consumer characteristics in the food products:

	A	B	C
i) Color			
ii) Taste and smell			
iii) Texture			
iv) Any other			

3. Are the products consumed alone - Yes/No. If the answer is no, describe briefly how they are consumed.

A	B	C

4. In the space given below, describe the methods of preparation of food products and circle the material used for the preparation:

(i) Desi/kabuli chickpea; (ii) whole seed/dhal (decorticated split seed)/dhal made into a flour. Also, indicate the proportions of (i) and (ii) used in the product.

A B C

5. Indicate the preferred characteristics in whole seed, dhal and flour:

	Whole seed	Dhal	Flour
i) Desi or kabuli			
ii) 100-seed weight (approximate)			
iii) Color			
iv) Cooking quality (cooking time etc)			
v) Normal period of storing of flour in household before use			

6. Your guestimate production of desi and/or kabuli chickpeas in your country:

Total production:__________ Desi: __________; Kabuli __________

7. i) Approximate cost of 1 kg of chickpea in local currency: (1$ = _____)

Whole seed: _________; Dhal: _________; Flour _________

7. ii) Give the names of two of the most popular chickpea cultivars in your area/country:

8. Usual methods of processing of chickpeas in your country:

9. What proportion of consumption is in the form of whole seed (   ); dhal (   ); or flour (   ).

10. Is dhal preparation from whole seed a commercial (or) household activity ?

11. What proportion of chickpea produced is marketed ?

12. Is there a long distance trade in chickpea ? If yes - (i) in which form it is generally traded (circle the answer):

    Whole seed   Dhal   Flour

    (ii) What is the normal storage loss at farm levewl ______% and hosehold level ______%

13. Any other details you may wish to add: (Please continue in the last page if necessary).

14. Your name: Area(s) of interest:

    Mailing address:

APPENDIX - II

CHICKPEA PROTEIN CONTENT OF BREEDING LINES

S. No.	Lab. No.	Pedigree	Trial	Protein (%)	
				Routine	Check
1	5211	ICCL-84215	ICSN-DS	18.2	-
2	5212	ICCL-84216	ICSN-DS	20.9	-
3	5213	ICCL-84220	ICSN-DS	21.3	-
4	5214	ICCL-84221	ICSN-DS	17.8	-
5	5215	ANNIGERI	CHECK	19.4	-
6	5216	ICCL-84229	ICSN-DS	17.6	17.6
7	5217	ICCL-84230	ICSN-DS	18.2	-
8	5218	ICCL-84232	ICSN-DS	19.5	-
9	5219	ICCL-84233	ICSN-DS	21.1	-
10	5221	ICCL-84234	ICSN-DS	20.9	-
11	5222	ICCL-84235	ICSN-DS	19.3	-
12	5223	ICCL-84236	ICSN-DS	18.6	-
13	5224	ICCL-84237	ICSN-DS	19.2	-
14	5225	ICCL-84238	ICSN-DS	17.9	-
15	5226	ICCL-84239	ICSN-DS	16.7	-
16	5227	ICCL-84240	ICSN-DS	19.5	-
17	5228	ICCL-84241	ICSN-DS	19.4	-
18	5229	ICCL-84242	ICSN-DS	22.9	22.6
19	5230	ICCL-84243	ICSN-DS	19.9	-
20	5231	ICCL-84244	ICSN-DS	18.7	-
21	5232	ICCL-84246	ICSN-DS	19.7	-
22	5233	ICCL-84247	ICSN-DS	19.2	-
23	5234	ICCL-84248	ICSN-DS	16.9	17.4
24	5235	ICCL-84249	ICSN-DS	17.7	-
25	5236	ICCL-84250	ICSN-DS	18.7	-
26	5236	ANNIGERI	CHECK	19.7	-
27	5237	ICCL-84251	ICSN-DS	19.0	-
28	5238	ICCL-84312	ICSN-DM	19.6	-
29	5239	ICCL-84313	ICSN-DM	19.0	-
30	5240	ICCL-84315	ICSN-DM	18.2	18.7
31	5241	ICCL-84317	ICSN-DM	20.4	-
32	5242	ICCL-84319	ICSN-DM	20.2	-
33	5243	ICCL-84320	ICSN-DM	20.5	19.9
34	5244	ICCL-84323	ICSN-DM	19.4	-
35	5245	ICCL-84333	ICSN-DM	20.0	-
36	5246	ICCL-84334	ICSN-DM	18.4	-
37	5247	ICCL-84335	ICSN-DM	20.4	-
38	5248	ICCL-84336	ICSN-DM	17.9	-
39	5249	ICCL-84337	ICSN-DM	17.9	-
40	5250	ICCL-84338	ICSN-DM	17.0	-
41	5251	ICCL-84339	ICSN-DM	16.8	17.3
42	5252	ICCL-84340	ICSN-DM	19.9	-

Cont

APPENDIX - II

S. No.	Lab. No.	Pedigree	Trial	Protein (%)	
				Routine	Check
43	5253	ICCL-84341	ICSN-DM	18.6	-
44	5254	ICCL-84342	ICSN-DM	17.9	-
45	5255	ICCL-84343	ICSN-DM	18.8	-
46	5256	ICCL-83214	ICCT-DS	19.1	18.7
47	5257	ANNIGERI	CHECK	20.1	-
48	5258	ICCL-83328	ICCT-DS	18.4	-
49	5259	HDN-9-3	GIET	19.3	-
50	5260	H-83-200	GIET	18.5	-
51	5261	13-7	GIET	18.1	-
52	5262	BGM-437	GIET	17.4	-
53	5263	KPG-70	GIET	17.7	-
54	5264	SG-1	GIET	18.4	18.2
55	5265	ICCC-42	GIET	17.2	-
56	5266	ANNIGERI	GIET	16.2	16.1
57	5267	PDG-83-33	GIET	18.7	-
58	5268	ICCC-44	GIET	20.0	-
59	5269	JGJ-1	GIET	18.1	-
60	5270	GG-715	GIET	19.7	-
61	5271	ICCC-45	GIET	17.6	-
62	5272	DG-82-4	GIET	19.1	-
63	5273	SG-2	GIET	19.6	-
64	5274	ICCC-46	GIET	19.1	-
65	5275	BGM-435	GIET	18.6	-
66	5276	PDG-83-13	GIET	18.6	-
67	5277	KPG-24	GIET	19.9	20.2
68	5278	ANNIGERI	CHECK	19.1	-
69	5279	BGM-436	GIET	19.1	-
70	5280	GPF-7023	GIET	19.3	-
71	5281	BG-299	GIET	18.1	-
72	5282	BGM-438	GIET	16.0	16.1
73	5283	KPG-36	GIET	19.1	-
74	5284	DG-82-12	GIET	18.5	-
75	5285	BEG-482	GIET	19.9	-
76	5286	BG-300	GIET	19.9	-
77	5287	GPF-7022	GIET	18.1	-
78	5288	BG-297	GIET	19.3	-
79	5289	PDG-83-34	GIET	17.9	-
80	5290	ICPG-59	GIET	17.5	17.6
81	5291	GG-575	GIET	18.7	-
82	5292	K-82-19	GIET	19.2	-
83	5293	ICCC-43	GIET	19.7	-
84	5294	GNG-169	GIET	21.1	-
85	5295	GG-549	GIET	19.5	-
86	5296	BG-304	GIET	21.2	21.2
87	5297	BGM-435	GIET	20.1	-

Cont

APPENDIX - II

S. No.	Lab. No.	Pedigree	Trial	Protein (%) Routine	Protein (%) Check
88	5298	ICCC-46	GIET	20.1	-
89	5399	ANNIGERI	CHECK	19.9	-
90	5300	KPG-70	GIET	18.9	-
91	5301	PDG-83-33	GIET	19.8	-
92	5302	BDG-482	GIET	19.9	-
93	5303	GG-549	GIET	20.3	20.7
94	5304	H-82-19	GIET	20.1	-
95	5305	KPG-59	GIET	17.3	17.4
96	5306	BGM-436	GIET	20.2	-
97	5307	BGM-437	GIET	18.7	-
98	5308	BG-304	GIET	18.9	-
99	5309	DG-82-12	GIET	20.8	-
100	5310	GPF-7023	GIET	23.1	-
101	5311	KPG-36	GIET	19.4	-
102	5312	BG-1	GIET	19.4	-
103	5313	BG-297	GIET	19.2	19.3
104	5314	JGJ-1	GIET	20.2	-
105	5315	13-7	GIET	20.9	-
106	5316	GPF-7022	GIET	19.2	-
107	5317	GG-575	GIET	20.6	-
108	5318	ICCC-44	GIET	19.5	-
109	5319	BDN-9-3	GIET	19.2	-
110	5320	ANNIGERI	CHECK	20.1	-
111	5321	ANNIGERI	GIET	18.3	-
112	5322	GG-715	GIET	23.4	23.3
113	5323	GNG-169	GIET	22.7	-
114	5324	DG-82-4	GIET	20.0	-
115	5325	PDG-83-13	GIET	20.1	19.8
116	5326	KPG-24	GIET	21.8	-
117	5327	SG-2	GIET	21.5	-
118	5328	BGM-438	GIET	20.4	-
119	5329	ICCC-42	GIET	19.7	-
120	5330	ICCC-45	GIET	19.4	-
121	5331	BG-299	GIET	21.6	-
122	5332	H-83-200	GIET	20.6	-
123	5333	ICCC-43	GIET	20.6	-
124	5334	BG-300	GIET	21.8	
125	5335	PDG-83-34	GIET	16.5	16.6
126	5336	GBS-1	CIET	18.5	18.4
127	5337	ICCC-30	GIET	18.6	-
128	5338	PBNG-34	GIET	19.4	-
129	5339	BDN-9-3	GIET	20.1	-
130	5340	BDNG-20	GIET	20.2	-

Cont.

APPENDIX - II

S. No.	Lab. No.	Pedigree	Trial	Protein (%)	
				Routine	Check
131	5341	ANNIGERI	GIET	19.3	-
132	5342	ICCC-39	GIET	20.3	-
133	5343	CO-2	GIET	19.8	-
134	5344	IG-5-14	GIET	22.0	21.4
135	5345	GBS-2	GIET	17.8	-
136	5346	CO-G-2	GIET	21.5	-
137	5347	BGM-426	GIET	18.6	-
138	5348	BDNG-25	GIET	20.4	-
139	5349	ANNIGERI	GIET	19.4	-
140	5350	BEG-482	GIET	17.2	-
141	5351	ICCC-36	GIET	19.9	-
142	5352	PHULEG-5	GIET	19.3	-
143	5353	ICCC-37	GIET	17.7	-
144	5354	P-1329	GIET	17.3	-
145	5355	GBS-2	GIET	16.3	16.2
146	5356	ANNIGERI	GIET	16.8	-
147	5357	CO-2	GIET	19.7	-
148	5358	IG-5-14	GIET	20.4	-
149	5359	GBS-1	GIET	19.9	-
150	5360	BDNG-20	GIET	18.2	-
151	5361	PHULEG-6	GIET	19.9	-
152	5362	ANNIGERI	CHECK	19.5	-
153	5363	BDNG-25	GIET	18.6	
154	5364	ICCC-39	GIET	22.1	21.9
155	5365	CO-G-2	GIET	21.8	21.7
156	5366	PBNG-34	GIET	18.8	-
157	5367	BDN-9-3	GIET	21.1	-
158	5368	ICCC-36	GIET	18.9	-
159	5369	BEG-482	GIET	20.9	-
160	5370	ICCC-30	GIET	20.0	-
161	5371	ICCC-37	GIET	18.7	-
162	5372	BGM-426	GIET	17.5	-
163	5373	P-1329	GIET	17.9	-
164	5374	ICCC-1	GIET	19.9	-
165	5375	ICCC-2	GIET	17.9	-
166	5376	ICCC-3	GIET	20.1	-
167	5377	ICCC-4	GIET	18.8	-
168	5378	ICCC-5	GIET	18.4	-
169	5379	ICCC-6	GIET	19.6	-
170	5380	ICCC-7	GIET	19.1	-
171	5381	ICCC-8	GIET	18.7	-
172	5382	ICCC-9	GIET	17.0	-
173	5383	ANNIGERI	CHECK	20.0	-
174	5384	ICCC-10	GIET	18.2	-
175	5385	ICCC-11	GIET	20.8	-

Cont.

S. No.	Lab. No.	Pedigree	Trial	Protein (%) Routine	Check
176	5386	ICCC-12	GIET	19.0	-
177	5387	ICCC-13	GIET	18.0	-
178	5388	ICCC-14	GIET	18.2	-
179	5389	ICCC-15	GIET	17.6	-
180	5390	ICCC-16	GIET	17.9	-
181	5391	ICCC-17	GIET	16.2	-
182	5392	ICCC-18	GIET	18.8	-
183	5393	ICCC-19	GIET	17.3	-
184	5394	ICCC-20	GIET	17.8	-
185	5395	ICCC-21	GIET	16.9	17.2
186	5396	ICCC-22	GIET	18.2	-
187	5397	ICCC-23	GIET	15.9	15.9
188	5398	ICCC-24	GIET	16.5	-
189	5399	ICCC-25	GIET	16.8	-
190	5400	ICCC-26	GIET	15.3	-
191	5401	ICCC-27	GIET	17.1	-
192	5402	ICCC-28	GIET	15.2	15.2
193	5403	ICCC-29	GIET	18.6	-
194	5404	ANNIGERI	CHECK	19.2	-
195	5405	ICCC-30	GIET	18.3	-
196	5406	ICCC-31	GIET	16.4	16.6
197	5407	ICCC-32	GIET	20.5	-
198	5408	ICCC-33	GIET	16.6	-
199	5409	ICCC-34	GIET	20.2	-
200	5410	ICCC-35	GIET	17.3	-
201	5411	ICCC-36	GIET	21.3	-
202	5412	ICCC-37	GIET	17.9	-
203	5413	ICCC-38	GIET	21.4	-
204	5414	ICCC-39	GIET	21.8	-
205	5415	ICCC-40	GIET	19.1	-
206	5416	ICCC-41	GIET	19.0	-
207	5417	ICCC-42	GIET	23.5	-
208	5418	ICCC-43	GIET	23.5	22.8
209	5419	ICCC-44	GIET	17.5	-
210	5420	ICCC-45	GIET	17.2	-
211	5421	ICCC-46	GIET	18.7	-
212	5454	ANNIGERI	CHECK	17.7	-
213	5455	K-850	ICCT-DS	19.7	-
214	5456	BDN-9-3	ICCT-DS	20.5	-
215	5457	ICCL-83227	ICCT-DS	21.1	-
216	5458	ICCL-83135	ICCT-DS	21.3	-
217	5459	ICCL-82115	ICCT-DS	20.9	21.5
218	5460	ICCL-81215	ICCT-DS	22.4	-
219	5461	ICCL-82108	ICCT-DS	17.7	-
220	5462	ICCL-82230	ICCT-DS	17.1	

Cont.

S. No.	Lab. No.	Pedigree	Trial	Protein (%) Routine	Check
221	5463	ICCL-83224	ICCT-DS	16.4	15.8
222	5464	ICCL-84215	ICCT-DS	16.6	-
223	5465	ICCL-84217	ICCT-DS	18.1	-
224	5466	ICCL-84219	ICCT-DS	20.2	-
225	5467	ICCL-84224	ICCT-DS	18.6	-
226	5468	ICCL-84225	ICCT-DS	16.4	16.6
227	5469	ANNIGERI	ICCT-DM	18.3	-
228	5470	K-850	ICCT-DM	20.6	-
229	5471	ICCV-1	ICCT-DM	18.0	-
230	5472	ANUPAM	ICCT-DM	20.2	-
231	5473	P-1506-3	ICCT-DM	20.2	19.9
232	5474	ANNIGERI	CHECK	19.9	-
233	5475	ICCL-84303	ICCT-DM	18.8	-
234	5476	ICCL-84311	ICCT-DM	18.3	-
235	5477	ICCL-84325	ICCT-DM	17.2	-
236	5478	ICCL-84327	ICCT-DM	16.8	-
237	5479	ICCL-84328	ICCT-DM	16.8	-
238	5480	ICCL-84334	ICCT-DM	17.1	-
239	5481	ICCL-84336	ICCT-DM	15.7	-
240	5482	ICCL-84337	ICCT-DM	15.0	14.9
241	5483	ICCL-84341	ICCT-DM	18.3	-
242	5484	ICCL-83228	ICCT-DM	16.5	-
243	5485	G-130	ICCT-DL	19.3	19.1
244	5486	PANTG-114	ICCT-DL	16.8	-
245	5487	H-81-73	ICCT-DL	21.4	-
246	5488	GNG-146	ICCT-DL	19.8	-
247	5489	ICCL-83448	ICCT-DL	16.1	-
248	5490	ICCL-84443	ICCT-DL	19.6	-
249	5491	ICCL-84460	ICCT-DL	19.6	-
250	5492	ICCL-85443	ICCT-DL	22.4	-
251	5493	ICCL-85444	ICCT-DL	21.2	-
252	5494	ICCL-85445	ICCT-DL	20.4	-
253	5495	ANNIGERI	CHECK	20.5	-
254	5476	ICCL-85446	ICC-DL	20.6	-
255	5497	ICCL-85447	ICC-DL	19.8	-
256	5498	ICCL-85448	ICC-DL	22.9	23.0
257	5499	ICCL-85449	ICC-DL	21.2	-
258	5500	P-1491-1	ICC-DL	20.4	20.2
259	5501	ICCL-82211	ICSN-DS	17.4	-
260	5502	ICCL-83205	ICSN-DS	14.4	14.8
261	5503	ICCL-84204	ICSN-DS	16.9	-
262	5504	ICCL-84205	ICSN-DS	16.9	-
263	5505	ICCL-84218	ICSN-DS	21.2	-
264	5506	ICCL-84223	ICSN-DS	17.6	-
265	5507	ICCL-84246	ICSN-DS	17.2	-

Cont.

S. No.	Lab. No.	Pedigree	Trial	Protein (%)	
				Routine	Check
266	5508	ICCL-84232	ICSN-DS	18.2	-
267	5509	ICCL-84239	ICSN-DS	18.8	18.7
268	5510	ICCL-12237	ICSN-DS	19.6	-
269	5511	ICCL-83149	ICSN-DS	19.0	-
270	5512	ICCL-82104	ICSN-DS	18.7	-
271	5513	ICCL-83128	ICSN-DS	17.8	-
272	5514	ICCL-82120	ICSN-DS	19.1	-
273	5515	ICCL-85201	ICSN-DS	21.4	-
274	5516	ANNIGERI	CHECK	20.4	-
275	5517	ICCL-85202	ICSN-DS	20.8	21.1
276	5518	ICCL-85203	ICSN-DS	21.3	-
277	5519	ICCL-85204	ICSN-DS	20.9	-
278	5520	ICCL-85205	ICSN-DS	19.9	-
279	5521	ICCL-85206	ICSN-DS	19.4	-
280	5522	ICCL-85207	ICSN-DS	20.1	19.4
281	5523	ICCL-85208	ICSN-DS	19.6	-
282	5524	ICCL-85209	ICSN-DS	17.4	-
283	5525	ICCL-85210	ICSN-DS	17.2	-
284	5526	ICCL-85211	ICSN-DS	19.4	-
285	5527	ICCL-85212	ICSN-DS	18.5	-
286	5528	ICCL-85213	ICSN-DS	16.9	16.8
287	5529	ICCL-85214	ICSN-DS	19.6	-
288	5530	ICCL-85215	ICSN-DS	17.2	-
289	5531	ICCL-85216	ICSN-DS	17.2	-
290	5532	ICCL-85217	ICSN-DS	20.4	20.8
291	5533	ICCL-85218	ICSN-DS	20.8	-
292	5534	ICCL-85219	ICSN-DS	19.1	-
293	5535	ICCL-85220	ICSN-DS	20.4	-
294	5536	ICCL-85221	ICSN-DS	18.1	-
295	5537	ANNIGERI	CHECK	18.8	-
296	5538	ICCL-85222	ICSN-DS	19.6	-
297	5539	ICCL-85223	ICSN-DS	19.3	-
298	5540	ICCL-85224	ICSN-DS	18.6	-
299	5541	ICCL-85225	ICSN-DS	20.6	-
300	5542	ICCL-85226	ICSN-DS	18.8	-
301	5543	ICCL-85227	ICSN-DS	19.8	-
302	5544	ICCL-85228	ICSN-DS	17.1	-
303	5545	ICCL-85229	ICSN-DS	18.8	18.8
304	5546	ICCL-85230	ICSN-DS	17.4	-
305	5547	ICCL-85231	ICSN-DS	19.0	-
306	5548	ICCL-85232	ICSN-DS	21.9	-
307	5549	ICCL-85233	ICSN-DS	21.0	-
308	5550	ICCL-85234	ICSN-DS	21.2	-
309	5551	ICCL-85235	ICSN-DS	21.8	-
310	5552	ICCL-10450	ICSN-DS	19.0	-

Cont.

S. No.	Lab. No.	Pedigree	Trial	Protein (%)	
				Routine	Check
311	5553	ANNIGERI	CHECK	19.3	-
312	5554	JG-62	ICSN-DS	20.8	-
313	5555	ICCL-84302	ICSN-DM	17.8	-
314	5556	ICCL-84304	ICSN-DM	17.8	-
315	5557	ICCL-84305	ICSN-DM	17.9	17.7
316	5558	ANNIGERI	CHECK	19.3	-
317	5559	ICCL-84309	ICSN-DM	18.8	-
318	5560	ICCL-84310	ICSN-DM	18.9	-
319	5561	ICCL-84328	ICSN-DM	20.3	-
320	5562	ICCL-84333	ICSN-DM	15.9	-
321	5563	ICCL-85301	ICSN-DM	19.8	-
322	5564	ICCL-85302	ICSN-DM	20.8	-
323	5565	ICCL-85303	ICSN-DM	17.7	-
324	5566	ICCL-85304	ICSN-DM	20.2	19.8
325	5567	ICCL-85305	ICSN-DM	20.4	-
326	5568	ICCL-85306	ICSN-DM	20.7	-
327	5569	ICCL-85307	ICSN-DM	20.0	-
328	5570	ICCL-85308	ICSN-DM	18.8	-
329	5571	ICCL-85309	ICSN-DM	19.2	-
330	5572	ICCL-85310	ICSN-DM	20.5	-
331	5573	ICCL-85311	ICSN-DM	20.0	-
332	5574	ICCL-85312	ICSN-DM	18.0	-
333	5575	ICCL-85313	ICSN-DM	20.4	19.4
334	5576	ICCL-85314	ICSN-DM	19.6	-
335	5577	ICCL-85315	ICSN-DM	17.9	-
336	5578	ICCL-85316	ICSN-DM	18.6	-
337	5579	ANNIGERI	CHECK	20.2	-
338	5580	ICCL-85317	ICSN-DM	20.0	-
339	5581	ICCL-85318	ICSN-DM	22.9	22.8
340	5582	ICCL-85319	ICSN-DM	21.4	-
341	5583	ICCL-85320	ICSN-DM	22.7	-
342	5584	ICCL-85321	ICSN-DM	22.6	-
343	5585	ICCL-85322	ICSN-DM	23.7	-
344	5586	ICCL-85323	ICSN-DM	20.2	-
345	5587	ICCL-85324	ICSN-DM	16.1	16.0
346	5588	ICCL-85325	ICSN-DM	21.7	-
347	5589	ICCL-85326	ICSN-DM	20.2	-
348	5590	ICCL-85327	ICSN-DM	21.8	21.2
349	5591	ICCL-85328	ICSN-DM	22.4	-
350	5592	ICCL-85329	ICSN-DM	19.5	-
351	5593	ICCL-85330	ICSN-DM	19.8	-
352	5594	ICCL-85331	ICSN-DM	17.2	-
353	5595	ICCL-8346	ICSN-DM	20.7	-
354	5596	ICCL-1956	ICSN-DM	17.0	-
355	5597	K-850	ICSN-DM	20.2	-

Cont.

S. No.	Lab. No.	Pedigree	Trial	Protein (%)	
				Routine	Check
356	5598	ICCV-1	ICSN-DM	17.5	-
357	5599	ICCL-84412	ICSN-DL	14.5	14.6
358	5600	ANNIGERI	CHECK	18.4	18.7
359	5601	ICCL-84431	ICSN-DL	20.7	-
360	5602	ICCL-84438	ICSN-DL	16.5	-
361	5603	ICCL-84452	ICSN-DL	19.2	-
362	5604	ICCL-84459	ICSN-DL	22.3	-
363	5605	ICCL-83408	ICSN-DL	19.5	-
364	5606	ICCL-83451	ICSN-DL	17.5	-
365	5607	ICCL-85401	ICSN-DL	20.6	-
366	5608	ICCL-85402	ICSN-DL	23.3	-
367	5609	ICCL-85403	ICSN-DL	24.2	23.9
368	5610	ICCL-85404	ICSN-DL	23.1	-
369	5611	ICCL-85405	ICSN-DL	21.9	21.2
370	5612	ICCL-85406	ICSN-DL	23.3	-
371	5613	ICCL-85407	ICSN-DL	22.1	-
372	5614	ICC-11666	ICSN-DL	18.1	-
373	5615	ICCL-85408	ICSN-DL	21.9	-
374	5616	ICCL-85409	ICSN-DL	23.1	-
375	5617	ICCL-85410	ICSN-DL	17.6	-
376	5618	ICCL-85411	ICSN-DL	17.8	-
377	5619	ICCL-85412	ICSN-DL	14.3	14.9
378	5620	ICCL-85413	ICSN-DL	17.9	-
379	5621	ANNIGERI	CHECK	19.2	-
380	5622	ICCL-85414	ICSN-DL	17.5	-
381	5623	ICCL-85415	ICSN-DL	18.5	-
382	5624	ICCL-85416	ICSN-DL	18.8	-
383	5625	ICCL-85417	ICSN-DL	18.0	-
384	5626	ICCL-85418	ICSN-DL	17.7	-
385	5627	ICCL-85419	ICSN-DL	16.9	17.1
386	5628	ICCL-85420	ICSN-DL	18.5	-
387	5629	ICCL-85421	ICSN-DL	19.3	-
388	5630	ICCL-85422	ICSN-DL	24.0	24.2
389	5631	ICCL-85423	ICSN-DL	20.9	-
390	5632	ICCL-85424	ICSN-DL	21.5	-
391	5633	ICCL-85425	ICSN-DL	21.3	-
392	5634	ICCL-85426	ICSN-DL	21.8	-
393	5635	ICCL-85427	ICSN-DL	21.0	-
394	5636	ICCL-85428	ICSN-DL	21.5	-
395	5637	ICCL-85429	ICSN-DL	20.2	-
396	5638	ICCL-85430	ICSN-DL	21.0	-
397	5639	ICCL-85431	ICSN-DL	20.4	-
398	5640	ICCL-85432	ICSN-DL	22.1	-
399	5641	ICCL-85433	ICSN-DL	23.3	-
400	5642	ANNIGERI	CHECK	19.7	-

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S. No.	Lab. No.	Pedigree	Trial	Protein (%)	
				Routine	Check
401	5643	ICCL-85434	ICSN-DL	24.7	24.7
402	5644	ICCL-85435	ICSN-DL	20.3	-
403	5645	ICCL-85436	ICSN-DL	20.2	20.2
404	5646	ICCL-85437	ICSN-DL	22.1	-
405	5647	ICCL-85438	ICSN-DL	19.0	-
406	5648	ICCL-85439	ICSN-DL	17.9	-
407	5649	ICCL-85440	ICSN-DL	23.1	-
408	5650	ICCL-85441	ICSN-DL	21.6	-
409	5651	ICCL-85442	ICSN-DL	19.9	-
410	5652	G-130	ICSN-DL	17.8	-
411	5653	H-208	ICSN-DL	23.4	23.9
412	5654	ICCC-14	ICSN-DL	17.9	-
413	5655	ICCC-25	ICSN-DL	17.1	-
414	5656	ICCC-33	ICSN-DL	16.7	17.2
415	5657	ICCC-34	ICSN-DL	19.1	-
416	5658	ICCC-36	ICSN-DL	21.4	-
417	5659	ICCC-37(B)	ICSN-DL	17.4	-
418	5660	ICCC-38	ICSN-DL	20.9	-
419	5661	ICCC-39	ICSN-DL	21.5	-
420	5662	ICCC-40	ICSN-DL	19.2	-
421	5663	ANNIGERI	CHECK	19.2	-
422	5664	ICCC-41	CHECK	19.9	-
423	5665	ICCC-42	CHECK	21.8	-
424	5666	ICCC-43	CHECK	23.3	-
425	5667	ICCC-46	CHECK	20.5	-
426	5668	ICCC-47	CHECK	21.4	-
427	5669	ICCC-48	CHECK	20.2	-
428	5670	ICCC-30	CHECK	17.3	-

P I G E O N P E A

P-111(85)IC : Study some of the factors affecting the grain quality of pigeonpea

During this year we concentrated our efforts in the following areas:

1. Cooking quality
2. Milling quality
3. Protein content and amino acids
4. Chemical analysis of pod fly resistance and susceptible lines
5. Effect of spraying on grain quality

The results obtained in these areas of research activity have been summarised in this report.

1. Cooking quality :

Cooking time, water absorption, solids dispersibility and texture are considered important aspects of cooking quality. We studied these aspects in 80 advanced breeding lines by analysing their dhal samples. For the preparation of dhal, whole seed was processed by soaking it for 6 hr in sufficient quantity of distilled water. After soaking excess water was discarded and sample was dried at 55°C in the oven for about 16 hr overnight. The dried sample was decorticated using a barley pearler to obtain dhal samples.

Dhal samples were analysed for protein content, cooking time, water absorption, solids dispersed and texture using Instron Food Testing Machine. Previously standardized procedures were used for analysis of these characteristics. The results of these samples are presented in Appendix I. These lines were also analyzed for whole seed protein content and 100-grain weight recorded in order to study their relationship with cooking quality. Cooking time of these lines ranged between 20 and 40 min with mean being 29 min. Cooking time of check cultivars BDN 1 and C 11 was 24 and 26 min, respectively. While several lines required about 25 min to cook, about 35% of these lines showed cooking time higher than that of the C 11. These lines may be evaluated further during the next season to confirm their cooking quality characteristics.

The results on cooking time were substantiated by the values for water absorption, amount of solids dispersed during cooking and texture of these lines. As shown in Table 1, cooking time was negatively and significantly correlated with water absorption (r = -0.34**) and solids dispersed (r = -0.69**) and positively correlated with texture (r = 0.70**), 100-grain weight was negatively and significantly correlated (r = -0.33**) with the dhal cooking time. No significant correlation between protein content and cooking time was observed. Based on these correlations, it may be suggested that such objective characteristics as water absorption, solids dispersed and texture could be used as an index of cooking quality.

Another lot of genotypes including ICPL 87 were evaluated for cooking quality. Cooking time, water absorption and solids dispersed were determined in whole seed and dhal samples of these genotypes (Table 2). Some differences in the cooking time of these genotypes were observed. Cooking time of ICPL 87 was lower than C 11 when former was obtained from the breeding program. ICPL 87 obtained from the Resource Management Program required slightly longer time to cook than C 11 indicating some differences due to the origin of material. Cooking time of whole seed was nearly two and a half times higher than that of the dhal sample (Table 2).

2. **Milling quality:**

Efforts were made to determine the milling quality of pigeonpea cultivars using the facility of a commercial dhal mill in Hyderabad (Shri Ram Dhal Mill, Bhadurpura, Hyderabad). Although it may be difficult to use the procedure of a commercial dhal mill for evaluating cultivars as it would require a large quantity of seed material (about 100 kg), this exercise was carried out to compare the results of a commercial dhal mill with that of other laboratory procedures which could process a smaller quantity. About 100 kg each of C 11, ICPL 7041, and ICP 276 were processed by following a standard procedure of this commercial dhal mill. Seed sample was treated with edible oil (linseed oil) at a rate of approximately 250 g/100 kg seed material. After this treatment, material was stored in a gunny bag overnight at room temperature (27°C) and then repeatedly passed through a roller machine until processed into different fractions. The roller machine that involves an abrasive action was used for dehusking purpose. Different fractions such as dehusked cotyledons (unsplit), brokens, husk, and powder, were collected. Dehusked unsplit material was further treated with water (about 3 liters/100 kg dehusked material) and kept in a heap for 3-4 hr. This was followed by sun drying for about 6-7 hr or until dried. Thus treated and dried dehusked unsplit cotyledons were passed through another roller machine to obtain dhal ie, decorticated split cotyledons.

The percentages of different fractions obtained as a result of milling are given in Table 3. Dhal yield ranged between 75.9 and 79.2%, being highest for C 11 and lowest for ICPL 7041. Lower dhal yield in case of ICPL 7041 might have been due to its smaller seed size as a result of which more powder fraction was obtained. Total recovery varied from 96.3 to 99.4%. To compare the results of the commercial dhal mill, it is planned to process these cultivars using Tangential Abrasive Dehulling Device (TADD), barley pearler and a manually operated stone-chakki.

Efforts were made to study the milling quality of some genotypes by using a barley pearler. By employing similar conditions of processing, ICPL 87, ICPL 304, and C 11 were processed into dhal, broken, powder, and husk fractions (Table 4). Milling quality of ICPL 87 and C 11 seems to be comparable. However, the amount of undehusked material was more in ICPL 87 as compared to C 11. Dhal yield was very low in case of ICPL 304 and this might have been due to larger quantity of seed material left undehusked using similar assay conditions. More efforts in this direction will be useful.

3. Protein content and amino acids :

We continued to monitor the protein content of breeding material and during this year we analyzed 2948 dhal smples and 396 whole-seed samples. The protein content was determined by Technicon Auto Analyser. Total nitrogen was determined and converted into protein by using a factor of 6.25. For the preparation of dhal, whole seed samples were soaked in distilled water at 5°C overnight and seed coat was removed manually. Dhal samples were dried in the oven at 55°C and ground to a fine powder using a Udy cyclone mill. The protein content in dhal samples varied from 16.2 and 35.5% and in the whole seed samples from 15.5 to 22.5%. One lot of 783 whole-seed samples of germplasm accessions were also analyzed for protein content which ranged between 14.7 and 23.7%.

An experiment was conducted to study the protein accumulation in a high-protein line (HPL 26) in comparison with a check? cultivar (BDN 1). Samples were collected at different stages of grain development and analyzed. These lines were grown during the 1984 rainy season at ICRISAT Center. Leaf samples were also collected at 45, 70, and 105 days after planting of these lines. Seed and leaf samples were freeze-dried and analyzed for total nitrogen and results are summarised in Table 5. Although the seed protein content of the high protein line was noticeably higher as compared to BDN 1 as the seed matured, the differences were more pronounced during the later stages of maturation. Grain weight of the high protein line was lower than BDN 1 during the later stages of maturation. Nitrogen analysis of leaf samples indicated that nitrogen content of HPL 26 was lower than BDN 1 at 45 and 70 days after planting.

Amino acid composition of seed protein is very important from nutrition point of view. Amino acid composition of ICPL 87 was determined in whole seed and dhal samples (Table 6). No noticeable differences in the amino acid composition of ICPL 87 were observed when the results were compared with those reported earlier excepting slightly lower values for lysine. This was observed to be the case for both whole seed and dhal samples. Amino acid analysis of several high protein lines and their parent material was carried out. No large differences were observed in the sulphur amino acids and lysine content of these lines in comparison with their parent material (Table 7 - 10). This indicates that protein quality is not adversely affected by increasing the protein.

4. Chemical analysis of podfly resistant and susceptible lines :

Some concern has been expressed regarding the possible role of chemical constituents in insect resistance mechanism of a cultivar. We have conducted such studies earlier and continued to analyse many samples from the pulse entomology subprogram. During this year, three cultivars each of low podfly and high podfly groups were analyzed. Four replications each of these lines were grown at ICRISAT Center during the 1984 rainy season and analyses for pod wall and seed (immature) conducted. Total soluble sugars and phenolic compounds were estimated in pod wall samples whereas protein sugars and phenolic compounds were estimated in seed samples (Table 11). No clear cut differences between susceptible and resistance lines were obtained with respect to the contents of these compounds. Soluble sugar content was considerably higher in pod wall tissue of ICP 7337 (7.4%) as compared to other genotypes which ranged between 3.2 and 4.4%. Such a difference in soluble sugar content of immature seed was not observed.

5. **Effect of insecticide spraying on protein content and soluble sugar content of seed**

To study this effect, ICPL 87 was grown in 1984/85 season at ICRISAT Center and different insecticide sprays were given by our entomologists as shownin Table 12. Soluble sugar content of seeds of these treatments ranged between 5.35 and 5.91% indicating small variation. All the spray treatments including water showed lower protein values as compared to the control although the differences were small (Table 12). These preliminary results indicate spray treatment might decrease the protein content of seed. Additional studies in this direction will be useful.

Future plans

Evaluation of advanced breeding lines for organoleptic properties, cooking quality and nutritional quality will be continued. Starch properties will be studied in cultivars showing large differences in cooking quality. Protein analysis of breeding material and some germplasm accessions will be continued.

Antinutritional factors, protein digestibility and amino acid composition of igh protein lines (HPL) will be determined. Protein digestibility will be determined by conducting rat feeding experiments. Effect of cooking on protein digestibility will be studied by conducting rat feeding trials.

Different methods of milling will be studied and compared for their suitability. Influence of milling on nutritional quality will be studied.

Table 1 : Correlation matrix of various cooking quality characteristics of dhal of advanced breeding lines of pigeonpea.

Constituent	1	2	3	4	5	6
1. 100-Seed wt.	-	-	-	-	-	-
2. Dhal protein (%)	0.057	-	-	-	-	-
3. Whole seed protein (%)	0.191	0.649**	-	-	-	-
4. Cooking time (min)	-0.325**	-0.328**	-0.406**	-	-	-
5. Solids dispersed (%)	0.288*	0.356**	0.485**	-0.694**	-	-
6. Water absorption (g/g)	0.076	0.222	0.179	-0.344**	0.378**	-
7. Texture (kg)	-0.146	0.241*	-0.230	0.701**	0.651**	-0.352

*, and ** significant at 5% level and 1% level, respectively

Table 2 : Cooking quality analysis of some genotypes of pigeonpea

Genotype	Cooking time (min)		Water absorption		Solids dispersed (%)	
	a	b	a	b	a	b
ICPL 87 (Brd)	64	20	1.20	2.10	18.9	55.3
ICPL 87 (FSRP)	66	28	0.98	1.32	18.0	30.0
ICPL 304	60	24	1.01	1.51	20.0	36.3
ICPL 270	58	22	1.15	1.90	24.3	54.3
C-11	64	26	1.02	1.33	20.2	32.1
Mean	62.4	24	1.07	1.63	20.3	41.6
SE	± 3.28	± 3.16	± 0.097	± 0.351	± 2.42	± 12.27

a = whole seed; b = dhal, Brd=Breeding sub-program;

FSRP = Farming Systems Research Program

Table 3 : Milling quality of pigeonpea cultivars processed by commercial dhal mill in Hyderabad.

Cultivar	100-grain wt (g)	Percent recovery				
		Dhal	Brokens	Husk	Powder	Total
C 11	10.5	79.2	2.3	11.7	6.2	99.4
ICPL 7041	7.3	75.9	2.4	7.7	12.0	98.0
ICP 276	9.8	77.9	2.3	8.0	8.1	96.3
Mean	9.2	77.7	2.3	9.1	8.8	97.9
SE	± 1.40	± 1.66	± 0.06	± 2.23	± 2.96	± 1.55

Table 4 : Milling quality of some genotypes of pigeonpea using Barley Pearler.

Genotype	Sample wt (g)	Unde-husked	Milling Fraction Recovery (%)				
			Dhal	Broken	Powder	Husk	Total
ICPL 87 (Brd)[a]	150.8	17.0	64.1	6.6	1.6	14.3	86.6
ICPL 87 (FSRP)[b]	150.5	15.7	65.0	7.3	3.1	10.0	85.4
ICPL 304	154.6	25.6	53.0	9.6	1.3	9.6	73.5
C-11	150.3	9.2	64.4	10.6	3.2	11.8	90.0
Mean	151.6	16.9	61.6	8.5	2.3	11.4	83.9
SE	± 2.01	± 6.74	± 5.76	± 1.89	± 0.99	± 2.14	± 7.18

[a]Breeding sub-program, [b]Farming Systems Research Program

Table 5 : Grain weight and protein content at different stages of grain development of a high protein line and cv BDN 1 grown in the rainy season of 1984/85 at ICRISAT Center.

Cultivar	Constituent	Days after flowering[a]				
		10	20	30	40	50
HPL 26	Protein (%)	33.6	27.1	23.6	23.5	25.4
		± 0.31	± 1.89	± 0.82	± 0.91	± 0.36
	100-grain wt (g)	0.3	1.7	6.4	6.4	7.6
		± 0.04	± 0.67	± 0.02	± 0.21	± 0.23
BDN 1	Protein (%)	36.3	25.5	22.7	19.0	17.5
		± 0.80	± 0.35	± 0.73	± 0.42	± 0.35
	100-grain wt (g)	0.2	2.2	6.0	8.9	9.5
		± 0.06	± 0.33	± 0.47	+ 0.66	± 0.57

[a] Values are averages of three determinations.

Table 6 : Amino acid composition (g/100g protein) of dhal and whole seed of ICPL 87 grown in 1984/85 season at ICRISAT Center

	ICPL 87	
	Whole seed	Dhal
Lysine	6.76	6.75
Histidine	3.67	3.69
Arginine	6.10	6.05
Aspartic acid	10.40	10.28
Threonine	3.36	3.31
Serine	4.67	4.78
Glutamic acid	19.62	19.14
Proline	4.58	4.46
Glycine	3.79	3.58
Alanine	4.41	4.07
Cystine	0.87	0.82
Valine	4.70	4.46
Methionine	1.29	1.28
Isoleucine	3.60	3.62
Leucine	6.85	6.98
Tyrosine	3.10	3.13
Phenylalanine	8.84	8.89
Total	96.61	95.29
Protein % in sample[a]	19.68	22.30

[a]Protein (Nx6.25)

Table 7 : Amino acid composition (g/100g protein of normal and high protein lines of pigeonpea grown in 1983/84 season at ICRISAT center

Amino acid (g/100g protein)	Samples description				
	A. Scarabaeodes	HPL 2	HPL 19	HPL 26	A. Sericea
Lysine	6.59	6.69	6.24	6.60	6.58
Histidine	3.59	4.26	4.20	4.04	4.01
Arginine	6.75	7.84	5.95	7.33	6.82
Aspartic acid	9.88	10.10	9.87	9.58	9.90
Threonine	3.89	3.80	3.58	3.55	3.86
Serine	4.97	5.14	4.78	4.80	4.76
Glutamic acid	17.57	18.34	18.23	18.03	17.73
Proline	5.06	5.66	5.70	5.52	5.84
Glycine	3.78	3.61	3.45	3.43	3.50
Alanine	4.36	4.63	4.49	4.52	4.49
Cystine	0.97	0.97	0.92	1.01	1.09
Valine	4.44	4.24	4.19	4.20	4.25
Methionine	1.78	1.49	1.33	1.56	1.71
Isoleucine	4.21	3.88	3.83	3.97	3.82
Leucine	7.33	7.29	7.07	7.32	7.05
Tyrosine	3.20	3.01	2.98	3.08	3.01
Phenylalanine	7.61	8.76	8.72	9.15	9.66
Total (ex. ammonia)	95.97	99.68	95.51	97.69	98.08
Total (Meth + Cys)	2.75	2.46	2.25	2.57	2.80
Protein % in sample[a]	25.0	28.5	28.9	30.2	27.4

[a]Protein (Nx6.25)

Table 8 : Amino acid composition (g/100g protein) of normal and high protein lines of pigeonpea grown in 1983/84 season at ICRISAT Center

Amino acid (g/100g protein)	Samples description				
	HPL 43	HPL 24	*A. albicans*	HPL 40	HPL 35
Lysine	6.80	6.79	6.95	6.92	6.82
Histidine	3.50	4.32	4.30	4.51	4.45
Arginine	7.26	7.68	6.64	7.76	8.16
Aspartic acid	8.24	9.62	9.86	10.26	10.11
Threonine	2.34	3.58	3.56	3.82	3.77
Serine	2.59	4.77	4.92	4.94	4.97
Glutamic acid	21.44	17.68	17.60	18.79	18.71
Proline	5.63	6.02	5.84	6.50	6.62
Glycine	3.40	3.46	3.57	3.61	3.56
Alanine	6.56	4.56	4.53	4.71	4.68
Cystine	0.81	1.00	0.87	1.15	1.03
Valine	5.26	4.24	4.15	4.44	4.40
Methionine	1.50	1.48	1.46	1.52	1.51
Isoleucine	4.52	3.79	3.86	3.97	3.94
Leucine	8.01	7.19	7.27	7.38	7.31
Tyrosine	2.72	2.98	3.03	3.12	3.07
Phenylalanine	7.99	8.27	8.45	8.67	8.80
Total (ex. ammonia)	98.57	97.42	96.85	102.06	101.91
Total (Meth + Cys)	2.31	2.48	2.33	2.67	2.54
Protein % in sample[a]	25.8	25.3	27.3	26.5	27.8

[a]Protein (Nx6.25)

Table 9 : Amino acid composition (g/100g protein) of normal and high protein lines of pigeonpea grown in 1983/84 season at ICRISAT Center

Amino acid (g/100g protein)	Samples description				
	HPL 37	Pant A-2	HPL 20	HPL 31	T-21
Lysine	6.88	6.67	6.76	6.87	6.66
Histidine	4.36	4.29	4.24	4.39	4.16
Arginine	7.80	6.47	7.12	7.56	6.35
Aspartic acid	9.63	9.74	9.62	9.92	9.98
Threonine	3.59	3.77	3.60	3.74	3.59
Serine	4.75	4.66	4.75	4.81	4.71
Glutamic acid	18.83	18.14	18.07	18.33	18.28
Proline	5.20	6.13	6.00	6.20	6.09
Glycine	3.61	3.45	3.52	3.54	3.44
Alanine	4.73	4.65	4.61	4.62	4.67
Cystine	0.97	1.17	0.96	1.14	1.05
Valine	4.50	4.34	4.28	4.37	4.13
Methionine	1.53	1.49	1.43	1.49	1.42
Isoleucine	4.02	3.90	3.87	3.96	3.82
Leucine	7.49	7.19	7.19	7.40	7.27
Tyrosine	3.10	3.07	3.06	3.12	2.99
Phenylalanine	9.02	9.34	8.43	8.39	8.90
Total (ex. ammonia)	100.01	98.48	97.52	99.85	97.55
Total (Meth + Cys)	2.50	2.66	2.39	2.63	2.47
Protein % in sample[a]	28.4	22.7	25.3	25.3	24.4

[a]Protein (Nx6.25)

Table 10 : Amino acid composition (g/100g protein) of normal and high protein lines of pigeonpea grown in 1983/84 season at ICRISAT Center.

Amino acid (g/100g protein)	Samples description				
	HPL 51	HPL 52	HPL 35	Baigani	ICPL 270
Lysine	6.66	6.40	7.78	6.73	6.65
Histidine	4.38	4.22	4.56	4.19	4.11
Arginine	8.02	7.55	8.25	6.62	6.61
Aspartic acid	9.56	9.79	10.11	10.24	9.69
Threonine	3.62	3.64	3.96	3.65	3.57
Serine	4.72	4.87	4.89	4.86	4.77
Glutamic acid	17.72	17.06	19.48	18.19	18.38
Proline	6.37	6.22	4.82	5.52	6.00
Glycine	3.38	3.39	3.67	3.49	3.42
Alanine	4.41	4.50	4.73	4.55	4.53
Cystine	1.17	1.25	1.20	1.17	0.84
Valine	4.00	4.32	4.61	4.25	4.14
Methionine	1.40	1.47	1.64	1.50	1.81
Isoleucine	3.68	3.81	4.47	3.82	3.79
Leucine	6.99	6.85	7.62	7.20	7.15
Tyrosine	2.91	3.30	3.27	3.14	3.05
Phenylalanine	8.28	8.05	9.01	8.87	9.00
Total (ex. ammonia)	97.29	96.40	103.02	97.98	97.49
Total (Meth + Cys)	2.57	2.72	2.84	2.67	2.65
Protein % in sample[a] (defatted moisture free)	28.1	28.0	25.1	23.7	24.2

[a]Protein (Nx6.25)

Table 11 : Protein, soluble sugars and phenolic compounds of pod wall, and immature whole seed of genotype showing variable response to pod fly attack in pigeonpea

Line/genotype		Pod wall		Seed (immature)		
		Sugars	Phenolics	Protein	Sugars %	Phenolics %
ICP-3615	LPF	3.9	8.10	20.0	5.2	2.0
PPE-36-2	HPF	4.1	8.0	21.3	5.2	2.1
ICP-7194-1	LPF	4.4	8.2	21.0	5.0	2.0
ICP-7337	HPF	7.4	8.2	20.3	5.7	1.4
ICP-7176-5	LPF	4.1	7.9	19.9	5.1	1.5
ICP-3940	HPF	3.2	8.8	20.5	4.7	1.6

LPF = Low pod fly; HPF = High pod fly.

Table 12 : Effect of insecticide spray on protein and soluble sugars contents of seed of ICPL 87 grown in 1984/85 season.

Treatment	Protein (%)	Sugar (%)
Endosulfan (0.07%)	17.78	5.36
Monochrotophos (0.04%)	18.70	5.35
DDT (0.1)	18.23	5.51
Cypermethrin (0.009%)	18.95	5.86
Water spray	18.58	5.91
Control (No spray)	19.55	5.78

[illegible] - I

PIGEONPEA : EVALUATION OF COOKING QUALITY OF ADVANCED BREEDING LINES

	Lab. No.	Genotype	100 seed weight (g)	Protein (%) Dhal	Protein (%) Whole seed	Cooking time (min)	Solids dispersed (%)	Water absorption (g/g)	Texture (Force/kg)
	11774	ICPL 81	7.1	21.6	17.9	34	29.1	1.66	210.0
	11775	ICPL 87	10.2	21.8	17.4	28	33.3	1.58	127.5
	11776	ICPL 141	7.8	21.8	18.4	28	33.1	2.20	142.5
	11777	ICPL 151	9.6	20.7	17.3	37	26.7	1.51	215.0
	11781	ICPL 186	8.8	22.3	16.7	28	29.6	2.08	158.5
	11782	ICPL 269	9.7	21.5	17.1	34	27.2	1.66	165.0
	11783	ICPL 289	9.6	18.6	15.9	26	28.7	1.89	90.0
	11784	ICPL 292	8.5	21.2	17.8	36	28.7	1.79	150.0
	11785	ICPL 312	11.3	21.5	19.5	28	40.1	2.07	160.0
	11786	ICPL 314	7.9	22.3	18.9	36	27.1	1.69	132.5
	11788	ICPL 317	8.6	21.2	15.2	40	30.7	1.94	137.0
	11789	ICPL 8301	6.8	19.4	16.1	36	28.4	1.73	242.8
	11790	ICPL 8303	7.5	22.4	18.7	32	32.7	2.13	157.5
	11791	ICPL 8306	7.1	21.5	18.7	32	37.9	1.78	127.5
5	11792	ICPL 8308	10.5	20.3	18.5	26	29.5	1.90	110.0
	11793	ICPL 8311	10.8	21.0	18.6	32	34.0	1.90	150.0
7	11795	ICPL 8320	10.7	20.7	16.9	28	29.4	1.91	130.0
	11796	ICPL 8321	9.3	21.0	17.0	38	27.3	1.90	175.0
9	11797	ICPL 8322	8.7	22.2	17.9	34	30.7	1.98	150.0
	11798	ICPL 8327	10.1	20.6	17.7	34	30.1	1.99	147.5
1	11799	ICPL 8328	7.5	19.6	15.9	34	21.1	1.94	162.5
2	11800	ICPL 8330	8.2	22.0	19.4	30	28.8	1.52	130.0
3	11801	ICPL 8332	9.9	20.7	17.9	28	34.0	1.71	190.0
4	11802	ICPL 84023	8.1	22.1	19.2	36	25.5	1.74	170.0
5	11803	ICPL 84026	8.3	19.6	17.4	32	31.7	1.57	170.0
6	11804	ICPL 84030	8.1	20.8	17.5	30	28.2	1.90	185.0
7	11805	ICPL 84032	10.1	21.8	17.2	36	31.1	1.76	165.0
8	11806	ICPL 84040	6.9	22.8	17.1	32	34.1	1.98	110.0
9	11807	ICPL 84042	7.4	21.4	17.6	30	38.1	1.88	87.5
0	11808	ICPL 84044	10.4	20.8	18.1	30	37.7	1.71	120.0
31	11809	ICPL 84052	8.1	20.1	17.5	28	40.3	1.76	125.0
2	11810	ICPL 84056	7.9	19.7	16.8	27	34.5	1.74	124.5
3	11812	ICPL 296	8.3	22.3	19.3	28	35.9	2.22	135.0
4	11813	ICPL 265	6.6	20.6	17.3	26	40.8	2.13	100.0
35	11814	ICPL 332	6.6	21.6	17.9	30	40.9	1.76	145.0
36	11815	ICPL 295	8.5	20.6	17.7	24	53.4	1.95	65.0
37	11816	BDN 1	10.1	23.0	18.2	24	44.7	1.64	95.0
38	11817	C 11	8.9	21.1	17.3	28	38.0	1.70	122.5
39	11988	ICPL 345	10.8	22.2	18.6	26	58.0	2.02	130.0
40	11989	ICPL 342	8.2	21.6	18.4	28	42.9	1.87	125.0
41	11990	ICPL 346	11.1	20.9	19.5	26	67.3	2.29	87.5
42	11991	ICPL 8350	9.7	21.0	19.5	26	40.1	1.81	130.0

APPENDIX - I

Sl. No.	Lab. No.	Genotype	100 seed weight (g)	Protein (%) Dhal	Protein (%) Whole seed	Cooking time (min)	Solids dispersed (%)	Water absorption (g/g)	Texture (Force/kg)
43	11992	ICPL 8349	8.5	20.9	17.8	32	44.1	1.97	197.5
44	11993	ICPL 8352	8.4	22.3	18.0	24	55.2	2.09	100.0
45	11994	ICPL 8343	11.8	20.9	16.5	24	47.7	1.70	107.5
46	11995	ICPL 343	9.3	19.6	16.3	36	38.3	2.10	147.5
47	11996	ICPL 376	9.0	22.5	19.3	28	43.9	1.62	105.0
48	11997	ICPL 8345	9.4	21.4	18.7	25	43.3	2.29	132.5
49	11998	BSMR 2	10.5	22.0	19.0	26	49.6	1.87	75.0
50	11999	ICPL 84070	11.2	21.8	19.4	26	45.4	1.82	112.5
51	12000	ICPL 84071	12.7	19.8	17.5	30	37.2	1.89	125.0
52	12003	ICPL 8356	9.7	22.3	18.9	24	60.0	1.98	65.0
53	12004	ICPL 333	9.8	23.2	19.5	24	53.7	2.05	60.0
54	12005	ICPL 8358	8.7	22.5	19.5	24	61.2	2.23	55.0
55	12006	ICPL 8357	9.2	21.4	17.9	26	50.4	1.59	107.5
56	12007	ICPL 8363	8.5	21.2	18.2	28	45.4	1.55	100.0
57	12009	DF 230	8.3	21.9	19.5	20	63.7	1.92	20.0
58	12010	ICPL 8362	8.3	20.7	16.9	24	49.2	1.74	80.0
59	12011	ICPL 335	9.1	21.2	17.7	26	47.5	1.68	100.0
60	12012	ICPL 84001	10.0	21.4	17.7	26	43.2	1.86	125.0
61	12013	ICPL 84002	11.2	21.2	17.5	26	54.6	1.78	80.0
62	12014	ICPL 84003	10.5	22.4	18.8	22	64.5	2.54	25.0
63	12015	ICPL 84005	11.4	21.4	18.8	22	46.4	1.96	135.0
64	12016	ICPL 84008	9.6	23.2	19.5	22	59.4	2.00	70.0
65	12017	ICPL 84011	9.7	22.7	18.9	22	60.7	2.01	60.0
66	12018	ICPL 84012	10.1	22.6	19.6	28	39.3	1.81	185.0
67	12019	ICPL 84016	9.7	22.8	19.5	24	53.8	2.06	85.0
68	12020	BWR 370	12.2	23.0	19.8	24	59.9	1.95	200.0
69	12022	ICPL 270	11.4	21.9	18.3	26	64.9	2.10	65.0
70	12023	HY 4	11.0	21.4	18.3	28	41.5	1.57	160.0
71	12024	ICPL 95	9.2	21.4	18.9	26	55.3	2.36	65.0
72	12025	ICPH 6	8.5	23.0	20.1	28	57.5	1.79	175.0
73	12026	PDM 1	8.8	22.5	19.3	28	50.8	1.86	90.0
74	12027	LRG 30	7.4	20.6	17.9	30	57.2	1.95	90.0
75	12028	ICPL 84060	7.9	22.0	19.2	36	27.1	1.69	195.0
76	12029	ICPL 84061	9.2	19.9	17.2	32	35.3	1.93	205.0
78	12030	ICPL 84062	8.4	19.9	17.1	30	41.6	1.74	145.0
79	12031	ICPL 84063	8.7	19.4	18.5	36	49.4	1.52	152.5
80	12033	ICPL 84065	10.6	20.5	18.3	32	54.2	1.54	148.5
	MEAN		9.2	21.3	18.1	29.3	38.0	1.9	126.5
	SE		±1.37	±1.02	±1.06	±4.45	±1.04	±0.21	+ 10.42